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ABSTRACT

This paper provides a framework for examining the role of argumentation and thinking and is consistent with the research on pedagogical and theoretical misconceptions. The focus is on presenting a framework to discuss and illustrate how argumentation is related to social thinking (dialogic reasoning) and conceptual change, and provide common examples of fallacious argumentation with an emphasis on socio-scientific reasoning. These include: (1) validity concerns; (2) naive conceptions of argument structure; (3) effects of core beliefs on argumentation; (4) inadequate sampling of evidence; and (5) altering representation of argument and evidence. Further, the role of anomalous information in changing pedagogical and conceptual misconceptions is addressed. Hypothetical samples of students' thoughts for analysis which exhibit various fallacious arguments and thinking and implications for science teaching are included. Contains 44 references. (LZ)

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Of Maggots and Saints: The Central Role of Fallacious Thinking in Science Teacher Education

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A summary of errors, biases, and fallacious thinking, and strategies for attending to pedagogical and conceptual misconceptions is presented. Paper Accepted for Presentation at the Annual Meeting of The Association for the Education of Teachers in Science and the National Science Teachers Association, Philadelphia, PA, March, 1995.

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Of Maggots and Saints: The Central Role of Fallacious Thinking in Science Teacher Education

Introduction

Are you not mad, my friend? What time o' the' moon is't?
Have not you maggots in your brain?
(John Fletcher, 1620)

Historically, having maggots in your brain was an appealing notion. Fanciful dance tunes of the 1700's by such titles as "Cary's Maggots" and "Barker's Maggots" celebrated whimsical, footloose and fancy-free character. The phrase, "When the maggot bites" quite literally suggested one who was swept away with capricious and fickle thoughts. Some suggested that if the maggot bite was hexagonal then poetry would consume that person; if circular...then eloquence; if conical...politics. (No reference is directly made about science educators.) But there is a fine line between being whimsical or imaginative, and the absence of level-headed thinking; being "mad as a hatter" as it were. (When mercurous nitrate was used to make felt for hats during this same time period, its poisonous effects produced a dance tune of a different, unstable rhythm: Saint Vitus's Dance) (Evans, 1989).

Few people in science teacher education would find fault with the ideological goal of scientific literacy expressed by Project 2061: that scientific habits of mind should be cultivated for all students to

> ...deal sensibly with problems that often involve evidence, quantitative consideration, logical arguments, and uncertainty; without the ability to think critically and independently, citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems. (AAAS, 1989, p.13)

Understanding the central role of fallacious thinking is fundamental to the eventual success of realizing this goal in science teacher education. However, science educators are faced with a bit of a sticky wicket. The success of instructional suggestions are contingent upon the adequate education of preservice and inservice teachers in critical thinking and reasoning skills. But here is the rub. As with school students' thinking skill and preinstructional conceptual development, the patterns of thought develop over many years. Consequently, simply informing teachers that their reasoning skills are

fallacious, fickle, or mad as a hatter using direct instructional approaches would no doubt meet with much resistance and little success. Psychological responses to anomalous information has been described in the literature and may include ignoring, rejecting, excluding, abeyance, reinterpreting, making partial changes to one's conceptual framework, or complete conceptual reorganization (Chinn & Brewer, 1993). Thus, psychologically "safe" ways that are pedagogically effective to revise preservice and inservice teachers' beliefs and reasoning are needed.

This paper will provide a framework for examining the role of argumentation and thinking and is consistent with the research on pedagogical and theoretical misconceptions. Addressing the central concerns of fallacious thinking is a concern to science teacher education. While the importance of critical thinking and discourse on argumentation, logical and moral reasoning has been presented elsewhere (Zeidler, Lederman, & Taylor, 1992), the present focus is on presenting a framework to discuss and illustrate how argumentation is related to social thinking (dialogic reasoning) and conceptual change, and present common examples of fallacious argumentation with an emphasis on socio-scientific reasoning. These will include (but not be limited to): 1) Validity Concerns ; 2) Naive Conceptions of Argument Structure; 3) Effects of Core Beliefs on Argumentation; 4) Inadequate Sampling of Evidence; and 5) Altering Representation of Argument and Evidence. Further, the role of anomalous information in changing pedagogical and conceptual misconceptions will be addressed. Hypothetical samples of students' thoughts for analysis which exhibit various fallacious arguments and thinking and implications for science teaching will be included.

Argumentation and Thinking

Teaching teachers about the role of fallacious thinking is premised on the larger issue of the importance of students' argumentation in everyday thinking. Most preservice or inservice teachers would tend to support the notion that scientific literacy entails at least in part, the ability for students to engage in active dialogue as they ponder evidence, apply critically thinking skills, and formulate positions on various topics. Informal discussions and formal debates play an important part in preparing students to utilize "argumentive thinking" as a vehicle by which they may come to terms with socio-scientific issues. Moreover, if teachers come to view the development of concepts as a construction of shared social knowledge, then the study of argument becomes

central to science teacher education (Toulmin, 1958; Kuhn, 1992; Zeidler et al. 1992).

Examining thinking by way of argumentation means that we no longer investigate how an individual "acts on" a problem, focusing their cognitive structures on some task-specific goal. Presently, we are concerned about the construction of shared social knowledge; hence our attention turns to what the literature has termed "transactive discussions" (Berkowitz, 1985) and "dialogic argument" (Kuhn, 1992). Whereas problem solving, in the usual sense of the word, compels one to coordinate internal reasoning structures with some aspect of the physical world, dialogic reasoning (argument) compels one individual to coordinate his or her reasoning structures with those of another individual. The result is an exchange in which a "mutual bootstrapping" (a phase credited to Kohlberg (1981) in scoring moral discussions) occurs; each person's assertions that run counter to another's creates mutual dissonance. Each person is cognitively challenged during discourse to reflect upon both their own, beliefs, assertions and premises, and those of the other individual. The resulting discourse leads to a joint construction of shared social knowledge (though not necessarily shared beliefs). Dialogic reasoning is necessarily an active activity; we will undoubtedly fail to realize our goal of scientific literacy if we simply teach teachers about this practice, rather than involving them in the practice of constructive argumentation. Otherwise teachers will do no more for their students then what we have asked of them. But because the literature is replete with evidence of fallacious reasoning (Zeidler, et al. 1992), we need a non-threatened, psychologically safe way to expose the most common flaws. Discussions with inservice or preservice teachers using hypothetical examples may be one way to accomplish this objective.

Constructivism, Paradigm Shifts, and Brow Beating

Although constructivism has suffered a schizophrenic fate worse than Sibyl (Good (1991) points to 15 adjectives used in the literature to describe an array of constuctivist camps in which one may stake a claim), most educators would probably agree that students at the middle school, high school, or college levels come to our classrooms with prior, well entrenched cognitive and moral beliefs. This intellectual baggage has developed over time both formally and informally through a plethora of individual and social experiences. Those in

education affectionately refer to this baggage as a student's preinstructional beliefs. Changing adherence to students preinstructional beliefs is no small task following the pedagogical scheme of Posner, Strike, Hewson, and Gertzog (1982); we may be asking them to perform nothing short of a Kuhnian paradigm shift (Kuhn, 1970). But since the idea of dialogic interaction and argumentation involves attempting to find a fit among one's beliefs, other individuals' beliefs, and the problem solving tasks at hand, I am more inclined to agree with Duschl and Gitomer's (1991) presentation and contention of Laudan's (1984) reticulated view of theory change: that change (theory or conceptual) does not necessarily happen in incremental linear steps; rather mutual factors (other's perspectives) continually restructure, alter or fine tune a students goals, procedures, and personal knowledge. Regardless of whether the means of conceptual restructuring is induced by way of browbeating or dialogic argumentation, students will be confronted by anomalous data or points of view, and personal beliefs and theories will continuously be challenged. How may we come to understand students' reaction to such dissonant discourse?

Chinn and Brewer (1993) provide a powerful framework teachers can utilize to help them understand an individual's response to anomalous data. In their model, six types of responses allow a student to safeguard their prior beliefs, while the seventh type of response provides for acceptance of new data with a corresponding change in their prior beliefs. It is interesting to note that this view is consistent with Laudan's(1984) reticulated model for partial change to either one's ontological, methodological or axiological commitments. (Note that this model stands in contrast to Kuhn's view of a paradigam shift in which theory change (core beliefs) would correspond to a change in *all* ontological, methodological and axiological commitments.) This notion is particularly important in light of student discourse where one person's beliefs and evidence may be incongruous (anomalous) with those of another. Teachers need to realize that students will find ways to protect their prior beliefs against the positions held by others that are dissonant. The psychological features of one's responses to conflicting data are presented below (Chinn & Brewer , 1993, p. 13):

Table 1.

Type of response	Does the individual accept the data?	Does the individual explain the data?	Does the individual change theories?
Ignoring	No	No	No
Rejecting	No	Yes	No
Excluding	Yes or Maybe(a)	No	No
Abeyance	Yes	Not Yet(b)	No
Reinterpreting	Yes	Yes	No
Peripheral Change	Yes	Yes	Yes, Partly(c)
Theory Change	Yes	Yes	Yes(d)

(a) The individual may either accept the data as valid or remain agnostic about its validity.
(b) The individual expects that the data will be explainable by current theory at some future date.
(c) Only beliefs in the "protective belt" are changed.
(d) "Core beliefs" are changed.

Teachers who have used debate-type format or moral dilemma infusion units in their classrooms will attest to the fact that conflicting data, positions, arguments and the like, do not necessarily lead a student to alter their beliefs. As the above table clearly shows, students are likely to find ways to discredit conflicting information to protect their beliefs. While Chinn and Brewer's model was aimed at explaining scientific misconceptions, I am proposing that the model is pedagogically useful in conceptualizing and anticipating the problems teachers are likely to encounter during classroom discourse. In fact, I will go so far as to claim that a student's beliefs and convictions about moral, ethical or personal opinions are every bit as rigid, perhaps more so, than their preinstructional beliefs about various scientific phenomena. While it is not the intent of this paper to provide a conceptual analysis for this claim, suffice it to say that the characteristics of one's personal beliefs (entrenchment or conviction, ontological and epistemological commitments, plausibility of alternative theory or competing positions, characteristics of the conflicting data or credibility or the other's points, etc.) are at least similar to the features of beliefs about scientific theories. And whether our goal, as teachers, is to induce theory change, or have students arrive through discourse at a mutually satisfying position to resolve competing claims, we need to attend to the various pitfalls and fallacies along the way. Five broad categories of fallacious thinking common to classroom discourse have been synthesized from an array of diverse empirical (quantitative

and qualitative) and analytic research efforts. These categories are presented below with examples following in Appendix 1 "Samples of Thought".

Fallacious Argumentation

As teachers encourage more verbal discourse in their classes to engage students in making assertions, supporting and defending those claims through a well-developed line of reasoning and judging the efficiency of counter arguments during discussions of socio-scientific issues, it becomes increasingly important to become better acquainted with certain fallacies common to argumentation, and the sources of those errors.

Validity Concerns Most students can recognize valid deductive argument forms contained in syllogisms, where the conclusion is a necessary consequence of the premises regardless of the truth or falsity of the content contained in those premises. One of most common fallacies of the deductive argument form is *affirming the consequent* and can be illustrated as: "If predators are present, then the rodent population has decreased. The rodent population has decreased. Therefore, predators are present." This error, although naive, occurs because of the superficial resemblance between a valid and nonvalid argument form and their resulting conclusions.

There are, however, even more subtle errors that are invoked when personal beliefs are at stake; viz.; confusion between truth and validity. Numerous studies have been cited where people are more apt to claim that a valid conclusion can be made from an argument if they believe the premises to be empirically true than if they believe them to be empirically false (Nickerson, Perkins, & Smith, 1985). When personal beliefs were incongruent with a valid argument form, their decision was not to choose the conclusion consistent with their belief, but to maintain that no conclusion was possible (Revlin, Leirer, Yopp, & Yopp, (1980). Here we see an example of people's responses to anomalous data by either ignoring, rejecting or excluding information when it conflicts with their beliefs. Notice that Chinn and Brewer's (1983) model suggests that an individual may accept data or arguments contrary to their own beliefs, but remain "agnostic" about its validity. "It is as if people appreciate the distinction between truth and validity, but fail to appreciate that in evaluating the logical soundness of a deductive argument validity alone is relevant" (Nickerson, et al., 1985, p.112).

Where students are required to apply hypothetico-deductive reasoning to evaluate the truth of certain hypotheses against external data, they are confronted with an inductive problem. Implications are deduced from the hypothesis and then checked against empirical evidence. In theory, if validity drawn inferences from the hypothesis lead to empirically false conclusions then the hypothesis is not supported (Gilhooly, 1988). But this view assumes a rather unimaginative interpretation of how students deal with propositional knowledge. The reason validity *is* a concern is because students are not isomorphic in their mental representations of the factors described by a given (or self-constructed) set of premises. The tacit beliefs and inferences students bring to bear on a problem may conflate the truth and validity of alternative scenarios. In discussing the nature of propositional reasoning, Johnson-Laird (1983, p.62) suggested that "...conditionals are not creatures of a constant hue. Like chameleons,... they take on the colour suggested by their surroundings." The realization that application of validity in argumentation may be influenced by nature of the problems and the commitment to prior beliefs is consistent with the observations of Kuhn, Amsel, & O'Loughlin (1988) who found that students either ignored covariation evidence that was not compatible with their initial theories, or modified the evidence to fit their theory. It was further suggested that the likelihood of reconciling personal theories with discrepant evidence decreased as the conviction to ones beliefs increased.

Naive Conceptions of Argument Structure Related to the issues addressed above, when students begin to formulate propositional arguments and counterarguments, their lack of a conceptual awareness about the structure of arguments gives rise to misconceptions about the validity of their claims. Perkins, Allen and Hafner (1983) have reported that students tend to rely on "makes-sense epistemology" (p.185); that is, whether or not a proposition seems intuitively correct. These individuals fail to scrutinize the form and validity of an argument if it "seems to be the case." In these cases, strategies that require more of an investment of cognitive energy are conserved in favor of heuristic strategies that generally require less critical effort and lead more swiftly to a conclusion. This explains why students may confuse the necessary conclusions of a deductive argument with the probabilistic conclusions of an inductive (inferential) argument. Relating this to Table One, we can realize that a counterargument may be held in "Abeyance", accepting the claims of another's

argument, but not attempting to integrate or explain those inconsistencies in relative to their own position thereby protecting their core beliefs.

Students use of their makes-sense epistemology can be expected to arise in many informal reasoning arguments that are inductive in nature. Wason's now familiar "four card problem" is telling of the tendency for individual's to rely on a pragmatic heuristic that is likely to support their contentions (1966; 1968; 1974). The problem here is that students are apt to selectively sample information that is consistent with their claims and ignore information that may be inconsistent (or falsifying) leading to a type of confirmation bias. Informal reasoning, after all, allows one to derive a wide set of inferences from a set of premises; it does not demand that *particular* conclusions be made. Johnson-Laird (1983) asserts that an essential element of reasoning is an "inferential heuristic" (p.71) that constrains the particular conclusions that may be drawn in a given situation. While it may be reasonable to assume that an inferential heuristic guides a student to make relevant conclusions with respect to particular claims and warrants, we must realize that relevant conclusions may very well be tainted by an over reliance on supporting evidence without adequate attention to disconfirming data. The literature is replete with examples of this tendency (Wason & Johnson-Laird, 1972; Wason & Evans, 1975; Snyder & Swann (1978); Griggs & Cox, 1982,1983; Evans, 1984; Cheng & Holyoak, 1985.)

Effects of Core Beliefs on Argumentation As students engage in dialogue they are inevitably compelled to seek warrants for their claims. In science classes, this typically takes the form of acquiring evidence to support one's position. While the tendency to have "blind faith" in supporting evidence (i.e. confirmation bias) was noted above, the effects of tendency on the student's core beliefs is important to note. For example, Lord, Ross, and Lepper (1979) study illustrates how subjects consistently evaluated "studies" of the effectiveness of capital punishment as a deterrent in a manner that favored their initial beliefs. Studies that were consistent with initial beliefs were a found to be more convincing for the subjects while studies that were counter to their initial beliefs were found to contain more flaws. Furthermore, the more entrenched one's initial beliefs were (e.g. beliefs in the "protective belt" verses "core" beliefs), the more polarized the beliefs became when confronted with mixed evidence. Baron (1985; 1988) and Baron & Brown (1991) describe this propensity as "belief persistence" and provide numerous additional examples from psychology of how prior beliefs compromise our ability to evaluate counter evidence and

criticism. The unsettling implication from these studies is that the more controversial the argument at hand, the more futile evidence contrary to one's position becomes. If this is true, then a possible claim (which has yet to be verified) is that the degree of polarization that may occur when counter arguments and evidence is confronted is directly related to the strength of initial core beliefs, and the likelihood of accepting or explaining the anomalous data is inversely related to the progression of theory change as presented in Table 1.

Inadequate Sampling of Evidence Students are not always required to challenge their core beliefs when confronted with competing claims; various issues and arguments may not even scratch their "protective belt" because they may not have vested interests in the topics at hand. But people are often called upon to advance a line of inquiry into areas that they have had little past experience. In these cases, the degree to which the student accepts novel data or attempt to explain conflicting data may have less to do with protecting a core belief, than knowing what counts as reasonable evidence. When students assert or accept a generalization on the basis of a sample that is neither sufficiently large or random, nor representative (transferable in the qualitative tradition, Lincoln and Guba, 1985), they commit the fallacy of hasty generalization.

The problem of hasty generalization is one that is rooted in inadequate sampling practices. What qualifies as acceptable evidence often differs across academic disciplines (and even within disciplines). Students, therefore, become unclear about what constitutes sufficient or convincing evidence. As is quite often the case, students are prone to rely on personal experiences to advance claims even though they could strengthen their positions by pursuing further gathering of evidence appropriate to that discipline. Both high school and higher education often produces students who are discipline-bound because instruction fails to make clear what counts as legitimate support for arguments differs across disciplines (e.g., statistical data, case studies, exemplars, principles, theory, authority, interviews, historical evidence, personal narrative, etc.). Consequently, this may lead students to treat argumentation as arbitrary, capricious and fickle inasmuch as teachers may not clearly convey the epistemological expectations of that discipline (Cerbin, 1988).

Common inadequate sampling practices that may result in hasty conclusions or generalization include the fact that students may seek too little information to warrant a firm conclusion or to achieve credibility in the transfer of particular instances to other settings. Conversely, students may seek to

acquire voluminous amounts of information. The problem now lies in the pitfall of unwittingly giving equal weight to all studies or sources of information. Students also tend to overemphasize the frequency of rare events that contain inherent shock value but underestimate the occurrences of more common events. Finally, students tend to have undue confidence in, and lack a functional understanding of, probabilistic and statistical information. There is a strong tendency for students to disregard base-rate information in favor of intuitive causal judgments. Their reliance on heuristics approaches to obtaining support for a position often results in unrepresentative samples and limited hypotheses that may not leave room for competing claims (Kahneman & Tversky, 1971, 1973; Lichtenstein, Slovic, Feschoff, Laymen, & Coombs, 1978; Tversky & Kahneman, 1982; Nickerson, Perkins & Smith, 1985; Kuhn, Amsel, & O'Loughlin, 1988).

Altering Representation of Argument and Evidence "Figures don't lie, but liars can figure!" is an all too familiar caveat in contemporary politics, educational statistics, and debate-type endeavors. Lying with the intent to deceive under most imperatives, is downright nasty. It assumes that the speaker is in possession of the "truth" but acts subversively by misrepresenting it to others (recall the misinformation tactics of political institutions during the Cold War). But what should we say when the facts, presuppositions, or premises of an initial problem or argument are inadvertently changed or modified by those involved in decision-making or argumentation? Certainly we should not think of our students as nasty beings, but when information is added, deleted, or misrepresented regarding a particular problem the net effect is the same. Perhaps, in an ironic way, this may be considered even more perverse because the reasoner is unaware that the problem at hand and the corresponding evidence is (self) tainted. Such premise conversion results in underdeveloped arguments at best and fallacious reasoning at worst. Sometimes this occurs because students introduce pragmatic inferences into a problem. They may make assertions about the context of a problem that ultimately change both the initial state of the problem under consideration, and the ensuing reasoning related to the problems resolution. When college students argued policy decisions related to socio-scientific problems, Zeidler and Schafer (1984) found that they confused hypothetical considerations and matters of fact with respect to the original premises of the problem when reasoning about those moral issues. Students interjected pragmatic inferences into the original problems in a manner that subtlety altered the initial dilemma. This is not unlike the findings of Kuhn

(1991) who closely examined the competence of argumentative reasoning for people in their twenties, forties, and sixties, and found that many exceeded the "boundaries of evidence" provided in a factitious scenario. In this case it seems that individuals also added a form of pragmatic inferences to the presented evidence by factoring their personal beliefs into the factitious scenario. Kuhn et al. (1988) has provided examples of misinterpretation of initial evidence (e.g. confusion of correlational with causational claims) in prior investigations. Other examples of altering evidence and premise conversion are replete in the literature (Baron, 1988; Nickerson et al., 1985; Perkins, et al., 1983; Revlin, et al., 1980).

Conclusion

The verdict is still out on the shape of the maggot's bite for science teacher education. The notion of having maggots on the brain has evolved from flights of fancy to something of more somber overtones in more recent history (recall the more colloquial expressions of "rats in the garret" and "bats in the belfry"). With renewed aims and goals in science education, we are revived and dance to new ideologies, saints, and sinners. But let us be prudent in our dance steps. Remember, there is a fine line between the deliberate movements of celebratory dance and the involuntary jerks of a nervous disorder. More attention to the central role of fallacious reasoning, pedagogical and conceptual misconceptions is warranted before we uncontrollably dance to new rhythms.

Appendix 1. Samples of Thought

(1) Validity Concerns

(Covariation: Colds)
A. (Do the findings of the scientists show that the kind of [variable] does make a difference, doesn't make a difference, or you can't tell what the scientists' findings show?) "Yes, because this one with this gum they were sick and this one they were not sick." (...for sure?) "Yeah." [Additional evidence presented.] (Does the kind of gum make a difference...? "Maybe. Gum could make a difference, but it wouldn't make you get a cold. (Do the findings of scientists show...?) "No, it doesn't make a difference. Gum is gum." [Additional evidence probe presented.] (Do the findings of scientists show...?) It makes a difference. They're still sick over here and here they're not sick." (Do scientists' findings tell you for sure that the kink of gum makes a difference?) "No. Gum does not get you colds."

(Covariation: Colds)
J. "Yes [the kink of sandwich makes a difference], because there aren't so many kids with colds." [Additional evidence presented.] "I don't know. " (Why not?) Because, you know, scientists they discover their things and people think other things. And breakfast rolls I'm not too high on, so I won't understand too much about it."

J. (Does the kind of sandwich make a difference...?) "Yes." (How do you know?) Because in Table 1, they had cheese sandwiches [and got no colds]. See, so it was more natural; they didn't have as much things [ingredients] as they do over here with the peanut butter sandwiches."

(2) Naive Conceptions of Argument Structure

(Starving Nation)
P. "I think population is the most important issue here. Yeah, it says that with a much smaller population Ruvaria would be able to support itself and allow people to live fuller and more comfortable and healthier lives. Therefore, I don't think he should give them the food...You know, when animals get up to too high a population, they start dying off."

(Children Failure in School)
H. (Is there anything someone could say or do to prove that this is what causes children to fail in school?) "Oh, I'm sure there are studies. I can't say that I follow through on any books or anything like that. but I'm sure there would be studies and this could be substantiated if I went to the library and looked up the subject of school, why they fail, et cetera. I'm sure I could find that." (How sure are you

of your view compared to an expert?) "Well, I feel I have enough experience to check on and consider whether they are on the right track. And Shanker in a recent article made me feel very good because he felt the same way I did. Even about merit pay."

(Children Failure in School)
(If you were trying to convince someone else that your view is right, what evidence would you give to try to show this?) "The point s that they get in school. The grades that they get in school to show..." (What would that show?) "That they are lacking something in their body. that the kids who were failing lack something [nutritional] in their body."

(3) Effects of Core Beliefs on Argumentation

(Starving Nation)
K. "If I were the president and I believed that God had powers in the first place to make a person's life end -- See, I don't even believe that God has anything to do with when your life ends."

(Starving Nation)
N. "Cause you're an atheist. See, I think you should get more objective about it. I mean, I believe in god but I'm not a devout Catholic or anything. I don't really feel that strongly about it, I just think that there is a superior being that is responsible for creating the world and everything. I don't know what He plays in it now so I just, you know look at it objectively."

(Heinz Dilemma III')
H. "[The judge should] Let him go free. Because he first went to the storekeeper like a good Muslim and asked for the food, but the storekeeper is not an understanding person, he did not give him food so he had to steal."

(Heinz Dilemma III')
S. "...And there are unwritten laws, and there are high values that I hold and if they conflict with law, perhaps I would consider violating that law." [How did that develop?] "I don't know. In my conscience. I don't know how early it developed, but in recent years I have worked in hospitals and seen people in dying conditions and I at least intellectually place a very high value on life, an high priority and I think it goes down into a feeling, it is not just an intellectualization."

(4) Inadequate Sampling of Evidence

(Environmental Strike)
V. "I think it's pretty important. I don't know -- I think if a lot of people realize that they were gonna be fired and love their job they might think twice about going out and strike -- and say, well, you know there is some pollution -- what the heck -- forget it when I can lose my money. Cause I know my mother is a teacher and she was on strike, and I now a lot of people crossed the picket line. and they know they were gonna be fired and lose their pay for each day they were out and they said -- forget it, we'll let the other people stand out there and be the suckers."

W. "And so what did your mother finally..."

V. "She stayed on strike and she lost quite a bit of money."

(Allocation of Scarce Resources)
N. "I don't think our town should be spending tax dollars for AIDS research. Only two case that I know of were reported in our [local] paper last year and everyone I know is against it anyhow. These facts do not justify us spending money when much more money is needed for other health issues."

(5) Altering Representation of Argument and Evidence

(Concerned Citizens)
M. "Oh, she does know him."

P. "She does?"

M. "Yeah, I think so."

P. "It doesn't really say that."

M. "No, she doesn't know him, I don't think so, so she's probably not concerned about that so much."

(Concerned Citizens)
I. "'Everytime someone escapes punishment for a crime, doesn't that just encourage more crime?' I don't think she would think of that."

G. "No, I don't either."

Sources for Appendix 1. Samples of Thought

(1) Kuhn et al. (1988 pp.72,81,82).
(2) Zeidler, (1982, p.79); Kuhn (1991, p.254); Kuhn (1991,p.87).
(3) Zeidler, (1982, p. 80; Kohlberg et al., 1978; Zeidler, 1990).
(4) Zeidler, (1982, p.80); Zeidler et al. (1992, p.442).
(5) Zeidler, (1982, p. 82); Zeidler & Schafer (1984, p.9)

References

American Association for the Advancement of Science. (1989). Project 2061: Science for all Americans. Washington, DC: Author.

Baron, J. (1985). Rationality and intelligence. Cambridge; Cambridge University Press.

Baron, J. (1988). Thinking and deciding. Cambridge: Cambridge University Press.

Baron, J. & Brown, R.V. (1991). Toward improved instruction in decision making to adolescents: A conceptual framework and pilot program. In J. Baron & R.V. Brown (Eds.), Teaching decision making to adolescents. Hillsdale: Lawrence Erlbaum Associates, Publishers.

Berkowitz, M.W. (1985). The role of discussion in moral education. In M.W. Berkowitz, & F. Oser, (Eds.), Moral education: Theory and application. Hillsdale: Lawrence Erlbaum Associates, Publishers.

Cerbin, B. (1988). The nature and development of in formal reasoning. Paper presented at the 12th National Institute on Issues in Teaching and Learning, Chicago, IL (ERIC Document Reproduction Service No. 298 805).

Cheng, P.W. & Holyoak, K. J. (1985). Pragmatic reasoning schemas. Cognitive Psychology 17, 391-416.

Chinn, C.A. & Brewer, W.F. (1993). The role of anomalous data in knowledge acquisition: A theoretical framework and implications for science instruction. Review of Educational Research, 63(1), 1-49.

Duschl, R. A. & Gitomer, D.H. (1991). Epistemological perspectives on conceptual change: Implications for educational practice. Journal of Research in Science Teaching, 28(9), 839-858.

Evans, I.H. (1989). Brewer's dictionary of phrase and fable. New York: Harper Collins Publishers.

Evans, J. St. B.T. (1984). Heuristic and analytic processes in reasoning. British Journal of Psychology 75, 451-458.

Gilhooly, K.J. (1988). Thinking: Directed, undirected and creative. San Diego, CA: Academic Press.

Good, R. (1991). Constructivism's many faces. Paper presented at the Thirteenth Conference on Curriculum, Theory and Classroom Practice at the Bergamo Conference Center, Dayton, OH.

Griggs, R.A. & Cox, J.R. (1982). The elusive thematic-materials effect in Wason's selection task. British Journal of Psychology 73, 407-420.

Griggs, R.A. & Cox, J.R. (1983). The effects of problem content and negation on Wason's selection task. Quarterly Journal of Experimental Psychology 35A, 519-534.

Johnson-Laird, P.N. (1983). Mental models: Towards a cognitive science of language, inference, and consciousness. Cambridge: Harvard University Press.

Kahneman, D. & Tversky, A. (1971). Subjective probability: A judgment of representativeness. Cognitive Psychology, 3 430-454.

Kahneman, D., & Tvewrsky, A. (1973). On the psychology of prediction. Psychological Review, 80, 237-251.

Kohlberg, L., Colby, A., Gibbs, J., & Speicher-Dubin (1978). Standard form scoring manual. Cambridge: Harvard University.

Kohlberg, L. (1981). The meaning and measurement of moral development (Volume XIII: 1979 Heinz Werner Memorial Lectures). Worcester, MA: Clark University.

Kuhn, D. (1991). The skills of argument. Cambridge: Cambridge University Press.

Kuhn, D. (1992). Thinking as argument. Harvard Educational Review, 62(2), 155-178.

Kuhn, D., Amsel, E., & O'Loughlin, M. (1988). The development of scientific thinking skills. San Diego: Academic Press, Inc.

Kuhn, T.S. (1970). The structure of scientific revolutions. Chicago: The University of Chicago Press.

Laudan, L. (1984). Science and values: The aims of science and their role in scientific debate. Berkeley: University of California Press.

Lichtenstein, S., Slovic, P., Fischoff, B., Laymen, M., & Coombs, B. (1978). Judged frequency of lethal events. Journal of Experimental Psychology: Human Learning and Memory, 4, 551-578.

Lincoln, Y.S. & Guba, E.G. (1985). Naturalistic Inquiry. Newbury Park, CA: SAGE Publication, Inc.

Lord, C.G., Ross, L., & Lepper, M.R. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. Journal of Personality and Social Psychology, 37, 2098-2109.

Nickerson, R.S., Perkins, D. N., & Smith, E.E. (1985). The teaching of thinking. Hillsdale: Lawrence Erlbaum Associates, Publishers.

Perkins, D.N., Allen, R., & Hafner, J. (1983). Difficulties in everyday reasoning. In W. Maxwell (Ed.), Thinking: The expanding frontier. Philadelphia: The Franklin Institute Press, Inc.

Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66, 211-227.

Revlin, R., Leirer, V., Yopp, H., & Yopp, R. (1980). The belief-bias effect in formal reasoning: The influence of knowledge on logic. Memory & Cognition, 8(6), 584-592.

Snyder, M. & Swann, W.B. (1978). Behavioral confirmation in social interaction: From social perception to social reality. Journal of Experimental Social aPaychology, 14, 148-162.

Toulmin, S.E. (1958). The uses of argument. Cambridge: Cambridge University Press.

Tversky, A., & Kahneman, D. (1982). Evidence impact of base rates. In D. Kahneman, P. Slovic, & A. Tversky (eds.) Judgment under uncertainty: Heuristics and biases. Cambridge: Cambridge University Press.

Wason, P.C. (1966). Reasoning. In B.M. Foss (Ed.), New horizons in psychology. Harmondsworth: Penguin.

Wason, P.C. (1968). Reasoning about a rule. Quarterly Journal of Experimental Psychology,20, 273-281.

Wason, P.C. (1974). New Scientist,63, 382-385.

Wason, P.C. & Evans, J. St. B.T. (1975). Dual processes in reasoning? Cognition 3, 141-154.

Wason, P.C. and Johnson-Laird, P.N. (1972). Psychology of reasoning: Structure and content. London: Batsford.

Zeidler, D.L. (1982). Identifying mediating factors of moral reasoning in science education. Doctoral dissertation, Syracuse University, Syracuse, NY.

Zeidler, D.L. (1990). [Assessing moral reasoning through discourse]. Unpublished raw data.

Zeidler, D.L., Lederman, N.G., & Taylor, S.C. (1992). Fallacies and student discourse: conceptualizing the role of critical thinking in science education. Science Education, 76(4), 437-450.

Zeidler, D.L. & Schafer, L.E. (1984). Identifying mediating factors of moral reasoning in science education. Journal of Research in Science Teaching, 21(1), 1-15.